

# Chlorine-containing organic constituents in chlorinated effluents

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RESIDUAL CHLORINE<sup>1</sup> from the chlorination of wastewater treatment plant effluents and other waters, such as cooling waters and industrial wastes, has biotoxic properties.<sup>2-4</sup> Residual chlorine, however, does not include stable chlorine-containing organic compounds that may have been produced during the chlorination process.<sup>5-7</sup> Relatively little is known about the formation of such compounds at the reaction conditions that exist during the chlorination of organic constituents at dilute concentrations such as those present in wastewater treatment plant effluents.<sup>8-10</sup> Assessment in terms of biohazards, cumulative effects, and the socioeconomics of the total ecological impact of chlorination of waters requires qualitative and quantitative information concerning the formation of chlorine-containing organic compounds during the chlorination process with milligram per liter concentrations of chlorine.<sup>2, 11</sup> The need for such information has become apparent with the recent determination of the detrimental ecological effects of certain chlorine-containing organic residues (for example, PCB, DDT, and DDT degradation products), which have now been found to be almost ubiquitous in the global environment.<sup>12, 13</sup>

This paper reports the results obtained by using a <sup>36</sup>Cl tracer, high resolution chromatographic method<sup>14, 15</sup> to make a detailed examination of the chlorine-containing compounds present in the chlorinated primary and secondary effluents from two domestic sanitary wastewater treatment plants.

## METHODS AND MATERIALS

**Effluent samples.** The wastewater treatment plants operated by the city of Oak

Ridge, Tenn., were selected as sampling locations. The wastewater of Oak Ridge (population 26,829 according to the 1970 census)<sup>16</sup> arises from an essentially pure domestic source. The Oak Ridge West Sewage Treatment Plant, which serves approximately 20,000 people, uses primary treatment with anaerobic sludge digestion and sludge recycling. Designed to process 5.0 mgd (18,900 cu m/day), it actually processes an average of 3.0 mgd (11,400 cu m/day). Before discharge to the receiving water system, the effluent is chlorinated with a concentrated aqueous solution of chlorine (average 420 mg/l). A combined chlorine residual (or)<sup>1</sup> of 1.0 mg/l is customarily maintained after a contact time of approximately 15 min.<sup>17</sup> The Oak Ridge East Sewage Treatment Plant, which serves approximately 7,000 people, uses both primary and secondary (activated sludge) treatment with anaerobic sludge digestion and sludge recycling for both the primary and secondary stages. Designed to process 1.5 mgd (5,680 cu m/day), it processes an average of 1.0 mgd (3,790 cu m/day). The effluent from the secondary stage is chlorinated with a concentrated aqueous solution of chlorine (average 580 mg/l). A combined chlorine residual (or) of 0.5 mg/l is normally maintained after approximately 30-min contact time before the effluent is discharged.<sup>15</sup>

The effluents of these plants were sampled by the grab technique before and after chlorination. The chlorinated samples were taken on a time-coordinated basis in order to make them representative of the effluent samples taken before chlorination. The sampling was scheduled in order to avoid periods of excessive rainfall. Descriptions of the effluent samples analyzed

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